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OBSERVATIONS

ON

The EXPECTATIONS of LIVES,

The INCREASE of MANKIND,

The Influence of great TOWNS on POPULATION,

AND PARTICULARLY

The STATE of LONDON,

WITH RESPECT TO

HEALTHFULNESS and Number of INHABITANTS.

Communicated to the ROYAL SOCIETY, April 27, 1769.

In a LETTER from

MR. RICHARD PRICE, F.R.S.

TO

BENJAMIN FRANKLIN, Esq; LL. D. and F. R. S.

LONDON,

Printed by W. BOWYER and J. NICHOLS,

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OF THE REVOLUTION

THE FIRST PART OF THE

THE SECOND PART OF THE

THE THIRD PART OF THE

AND THE FOURTH PART OF THE

THE FIFTH PART OF THE

WITH A PREFACE TO

THE HISTORY OF THE



Communicated to the Royal Society, April 17, 1780.

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A

L E T T E R

T O

BENJAMIN FRANKLIN, Esq;

LL.D. and F.R.S.

DEAR SIR,

I BEG leave to submit to your perusal the following observations. If you think them of any importance, I shall be obliged to you for communicating them to the Royal Society. You will find that the chief subject of them is the present state of the city of London, with respect to healthfulness and number of inhabitants, as far as it can be collected from the bills of mortality. This is a subject that has been considered by others; but the proper method of calculating from the bills has not, I think, been sufficiently explained.

No competent judgment can be formed of the following observations, without a clear notion of what

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the writers on *Life Annuities* and *Reversions* have called the *Expectation of Life*. Perhaps this is not in common properly understood; and Mr. De Moivre's manner of expressing himself about it is very liable to be mistaken.

The most obvious sense of the *expectation* of a given life is, "That particular number of years which a life of a given age has an equal chance of enjoying." This is properly the time that a person may reasonably *expect* to live; for the chances *against* his living longer are greater than those *for* it; and, therefore, he cannot entertain an *expectation* of living longer, consistently with probability. This period does not coincide with what the writers on Annuities call the *expectation of life*, except on the supposition of an uniform decrease in the probabilities of life, as Mr. Simpson has observed in his *Select Exercises*, p. 273.—It is necessary to add, that, even on this supposition, it does not coincide with what is called the *expectation of life* in any case of joint lives. Thus, two joint lives of 40 have an even chance, according to Mr. De Moivre's hypothesis*, of conti-

* Mr. De Moivre's hypothesis, here referred to, supposes (as is well known to those who have studied the subject of Life Annuities) an equal decrement of human life through all its stages. That is, it supposes that out of any given number alive at a given age, the same number will die every year till they are all dead. Thus; 86 Mr. De Moivre makes the utmost probable extent of life. The number of years which any given life wants of 86 he calls the *complement* of that life.—56, therefore, is the *complement* of 30; and supposing 56 persons alive at this age, one will die every year till, in 56 years, they will be all dead. The like will happen to 46 at 40, to 36 at 50, and so on, for all other ages. This is an
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ning together only $13\frac{1}{2}$ years. But the *expectation* of two equal joint lives being (according to the same hypothesis) always a *third* of the *common complement*, it is in this case $15\frac{1}{2}$ years. It is necessary, therefore, to observe, that there is another sense of this phrase which ought to be carefully distinguished from that now mentioned. It may signify "The *mean continuance* of any given *single, joint, or surviving* lives, " according to any given table of observations:" that is, the number of years which, taking them one with another, they actually enjoy, and may be considered as sure of enjoying, those who live or survive *beyond* that period, enjoying as much *more* time in proportion to their number, as those who *fall short* of it enjoy *less*. Thus, Supposing 46 persons alive, all 40 years of age, and that, according to Mr. De Moivre's *hypothesis*, one will die every year till they are all dead in 46 years, half 46 or 23 will be their *expectation of life*: that is; The number of years enjoyed by them all will be just the same as if every one of them had lived 23 years, and then died; so that, supposing no interest of money, there would be no difference in value between annuities payable for life to every single person in such a set, and equal annuities payable to another equal set of persons of the same common age, supposed to be all sure of living just 23 years and no more.

It is an excellent *hypothesis*. It eases exceedingly the labour of calculating the values of lives. It is remarkably agreeable to Dr. Halley's Table of Observations; and, as far as it implies an equal decrement of life, is, in a great measure, confirmed by other Tables.

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In like manner; the *third* of 46 years, or 15 years and 4 months, is the *expectation* of two joint lives both 40; and this is also the *expectation* of the survivor. That is; supposing a set of marriages between persons all 40, they will, one with another, last just this time, and the survivors will last the same time; and annuities payable during the continuance of such marriages would, supposing no interest of money, be of exactly the same value with annuities to begin at the extinction of such marriages, and to be paid, during life, to the survivors. In adding together the years which any great number of such marriages and their survivorships have lasted, the sums would be found to be equal.

One is naturally led to understand the *expectation* of life in the first of the senses now explained, when, by Mr. Simpson and Mr. De Moivre, it is called, *the number of years which, upon an equality of chance, a person may expect to enjoy*; or, *the time which a person of a given age may justly expect to continue in being*; and, in the last sense, when it is called, *the share of life due to a person* *. But, as in reality it is always used in the last of these senses, the former language should not be applied to it: and it is in this last sense that it coincides with the *sums* of the *present* probabilities that any given single or joint lives shall attain to the end of the 1st, 2d, 3d, &c. *moments* from this time to the end of their possible existence; or, in the case of survivorships, with the sum of the probabilities that

* See Mr. De Moivre on *Annuities*, p. 65, &c. 4th edition, and Mr. Simpson's *Select Exercises*, p. 255, 273.

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there shall be a survivor at the end of the 1st, 2d, 3d, &c. *moments*, from this time to the end of the possible existence of survivorship. This coincidence every one conversant in these subjects must see, upon reflecting, that both these senses give the true present value of a life-annuity secured by land, without interest of money*.

* The sum of the probabilities that any given lives will attain to the end of the 1st, 2d, 3d, &c. *years* from the present time to the utmost extremity of life (for instance, $\frac{4}{5} + \frac{3}{5} + \frac{2}{5}$, &c. to $\frac{1}{5} = 22\frac{1}{5}$ for lives of 40, by the *hypothesis*) may be called their *expectation*, or the number of payments due to them, as *yearly annuitants*. The sum of the probabilities that they will attain to the end of the 1st, 2d, 3d, &c. *half years* (or, in the particular case specified, $\frac{9}{10} + \frac{8}{10} + \frac{7}{10} + \frac{6}{10}$, &c. $= 22\frac{1}{2}$ *half years*, or $22\frac{1}{4}$ *years*) is their *expectation* as *half yearly annuitants*. And the sums just mentioned of the probabilities of their attaining to the end of the 1st, 2d, 3d, &c. *moments* (equal in the same particular case to 23 *years*), is properly their *expectation of life*, or their *expectation* as annuitants secured by land.

Mr. De Moivre has concealed the demonstrations of the rules he has given for finding these *expectations* of life, and only intimated, in general, that he discovered them by a calculation deduced from the method of fluxions, p. 66, of his *Treatise on Annuities*. It will, perhaps, be agreeable to some to see how easily they are deduced in this method upon the hypothesis of an equal decrement of life.

Let x stand for a moment of time and n the complement of any assigned life. Then $\frac{n-x}{n}$, $\frac{n-2x}{n}$, $\frac{n-3x}{n}$, &c. will be the *present probabilities* of its continuing to the end of the 1st, 2d, 3d, &c. *moments*; and $\frac{n-x}{n}$ the probability of its continuing to the end of x time. $\frac{n-x}{n} \times x$ will therefore be the *fluxion* of the sum of the probabilities, or of an *area* representing this sum, whose

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This period in *joint* lives, I have observed, is *never* ordinates are $\frac{n-x}{n}$, and axis x .—The *fluent* of this expression, or $x - \frac{x^2}{2n}$ is the sum itself for the time x ; and this, when $x=n$, becomes $\frac{1}{2}n$, and gives the *expectation* of the assigned life, or the sum of all the probabilities just mentioned for its whole possible duration.—In like manner: Since $\frac{n-x^2}{n^2}$ is the probability that two equal joint lives will continue x time $\frac{n-x^2}{n^2} \times x$ will be the *fluxion* of the sum of the probabilities. The *fluent* is $x - \frac{x^3}{n} + \frac{x^3}{3n^2}$, which when $n=x$ is $\frac{n}{3}$ the expectation of two equal joint lives.—Again: Since $\frac{n-x}{n} \times \frac{2x}{n}$ is the probability that there will be a survivor of two equal joint lives at the end of x time, $\frac{n-x}{n} \times \frac{2x}{n} \times x$ will be the *fluxion* of the sum of the probabilities; and the *fluent*, or $\frac{x^2}{n} - \frac{2x^3}{3n^2}$ is (when $x=n$) $\frac{1}{3}n$, or the *expectation* of survivorship between two equal lives, which therefore appears to be equal to the *expectation* of their joint continuance. The expectation of two *unequal* joint lives found in the same way is $\frac{m}{2} - \frac{m^2}{6n}$, m being the complement of the oldest life, and n the complement of the youngest. The whole *expectation* of survivorship is $\frac{n}{2} - \frac{m}{2} + \frac{m^2}{3n}$. The expectation of survivorship on the part of the oldest is, $\frac{m^2}{6n}$; and the expectation on the part of the youngest is, $\frac{n}{2} - \frac{m}{2} + \frac{m^2}{6n}$. It is easy to apply this investigation to any number of joint lives, and to all cases of survivorship.

I have above endeavoured to shew distinctly how the *expectations* of single lives may be found, agreeably to any Table of Observations, without having recourse to any principles, except such as are plain and common.

the same with the period which they have an equal chance of enjoying ; and in single lives, I have observed, they are the same only on the supposition of an uniform decrease in the probabilities of life. If this decrease, instead of being always uniform, is *accelerated* in the last stages of life, the former period, in single lives, will be *less* than the latter ; if *retarded*, it will be *greater*.

It is necessary to add, that the number expressing the former period, multiplied by the number of single or joint lives whose expectation it is added annually to a society or town, gives the whole number living together, to which such an annual addition would in time grow. Thus ; since 19, or the third of 57, is the *expectation* of two joint lives whose common age is 29, or common *complement* 57, twenty marriages every year between persons of this age would, in 57 years, grow to 20 times 19, or 380 marriages always existing together. The number of *survivors* also arising from these marriages, and always living together, would, in twice 57 years, increase to the same number. And, since the *expectation* of a single life is always half its *complement*, in 57 years likewise 20 single persons aged 29, added annually to a town, would increase to 20 times 28.5 or 570 ; and when arrived at this number, the deaths every year will just equal the accessions, and no further increase be possible.

It appears from hence, that the particular proportion that becomes extinct every year, out of the whole number constantly existing together of single or joint lives, must, wherever this number undergoes no
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variation,

variation, be exactly the same with the *expectation* of those lives at the time when their existence commenced. Thus; was it found that a 19th part of all the marriages among any body of men, whose numbers do not vary, are dissolved every year by the deaths of either the husband or wife, it would appear that 19 was, at the time they were contracted, the *expectation* of these marriages. In like manner; was it found in a society, limited to a fixed number of members, that a 28th part dies annually out of the whole number of members, it would appear that 28 was their common expectation of life at the time they entered. So likewise; were it found in any town or district, where the number of births and burials are equal, that a 20th or 30th part of the inhabitants die annually, it would appear that 20 or 30 was the *expectation* of a child just born in that town or district. These *expectations*, therefore, for all *single* lives, are easily found by a *Table of Observations*, shewing the number that die annually at all ages, out of a given number alive at those ages; and the general rule for this purpose is “ to divide
 “ the sum of all the living in the Table at the age
 “ whose expectation is required, and at all greater
 “ ages, by the sum of all that die annually at
 “ that age, and above it; or, which is the same, by
 “ the number in the Table of the living at that age;
 “ and half subtracted from the quotient will be the
 “ required *expectation*.” Thus, in Dr. Halley’s Table, the sum of all the living at 20 and upwards is 20,724. The number living at that age is 598; and the former number divided by the latter, and half

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half unity * subtracted from the quotient, gives 34.15 for the *expectation* of 20. The *expectation* of the same life by Mr. *Simpson's* Table, formed from the bills of mortality of London, is 28.9.

These observations bring me to the principal point which I have had all along in view. They suggest to us an easy method of finding the number of inhabitants in a place from a *Table of Observations*, or the *bills of mortality* for that place, supposing the yearly births and burials equal. " Find by the " Table, in the way just described, the *expectation* " of an infant just born, and this, multiplied by the " number of yearly births, will be the number of " inhabitants." At *Breslaw*, according to Dr. Halley's Table †, though half die under 16, and therefore an infant just born has an *equal chance* of living only 16 years, yet his *expectation*, found by the rule I have given, is near 28 years; and this, multiplied by 1238 the number born annually, gives 34,664.

* This subtraction is necessary, because the *divisor* ought to be made as much greater than the number dying annually given in the Table, as the *expectation*, with $\frac{1}{2}$ unity added, is greater than the *expectation*, on account of the number that will die, in the course of the year, out of those who are continually added, in order to preserve the number of the living the same.

In other words: If we conceive the *recruit* necessary to supply the *waste* of every year to be made always at the *end* of the year, the *dividend* ought to be the *medium* between the numbers living at the *beginning* and the *end* of the year; that is, it ought to be taken *less* than the sum of the living in the Table at and above the given age, by *half* the number that die in the year; the effect of which *diminution* will be the same with the *subtraction* I have directed.

† Vid. Lowthorp's Abridgment of the Philosophical Transactions, vol. III. p. 669.

the number of inhabitants. In like manner; it appears from Mr. Simpson's Table, that, though an infant just born in London has not an *equal chance* of living 3 years, his *expectation* is 20 years; and this number, multiplied by the yearly births, would give the number of inhabitants in London, were the births and burials equal. The medium of the yearly births, for the last 10 years, has been 15,710. This number, multiplied by 20, is 314,200; which is the number of inhabitants that there would be in London, according to the bills, were the yearly burials no more than equal to the births: that is, were it to support itself in its number of inhabitants without any supply from the country. But for the last 10 years, the burials have, at an average, been 22,956, and exceeded the christenings 7,246. This is, therefore, at present, the yearly addition of people to London from other parts of the kingdom, by whom it is kept up. Suppose them to be all, one with another, persons who have, when they remove to London, an *expectation* of life equal to 30 years. That is; suppose them to be all of the age of 18 or 20, a supposition certainly far beyond the truth. From hence will arise, according to what has been before observed, an addition of 30 multiplied by 7,246, that is 217,380 inhabitants. This number, added to the former, makes 531,580; and this, I think, at most, would be the number of inhabitants in London were the bills perfect. But it is certain that they give the number of births and burials too little. There are many burying-places that are never brought into the bills. Many also emigrate to the navy and army and country; and these ought to be added to the
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number of deaths. What the deficiencies arising from hence are, cannot be determined. Suppose them equivalent to 6000 every year in the births, and 6000 in the burials. This would make an addition of 20 times 6000 or 120,000 to the last number, and the whole number of inhabitants would be 651,580. If the burials are deficient only two thirds of this number, or 4000, and the births the whole of it; 20 multiplied by 6000, must be added to 314,290 on account of the defects in the births: and, since the excess of the burials above the births will then be only 5,246; 30 multiplied by 5,246 or 157,380, will be the number to be added on this account; and the sum, or number of inhabitants, will be 591,580. But if, on the contrary, the burials are deficient 6000, and the births only 4000; 80,000 must be added to 314,290, on account of the deficiencies in the births; and 30 multiplied by 9,246, on account of the excess of the burials above the births, and the whole number of inhabitants will be 671,580.

Every supposition in these calculations seems to me too high. *Emigrants* from London are, in particular, allowed the same *expectation* of continuance in London with those who are born in it, or who come to it in the firmest part of life, and never afterwards leave it; whereas it is not credible that the former *expectation* should be so much as half the latter. But I have a further reason for thinking that this calculation gives too high numbers, which has with me irresistible weight. It has been seen that the number of inhabitants comes out less on the supposition, that the defects in the christenings are greater than

than those in the burials. Now it seems evident that this is really the case; and, as it is a fact not attended to, I will here endeavour to explain distinctly the reason which proves it.

The proportion of the number of births in London, to the number who live to be 10 years of age, is, by the bills, 16 to 5. Any one may find this to be true, by subtracting the *annual medium* of those who have died under 10, for some years past, from the *annual medium* of births for the same number of years.—Now, tho', without doubt, London is very fatal to children, yet it is incredible that it should be so fatal as this implies. The *bills*, therefore, very probably, give the number of those who die under 10 too great in proportion to the number of births; and there can be no other cause of this, than a greater deficiency in the *births* than in the *burials*. Were the deficiencies in both equal, that is, were the *burials*, in proportion to their number, just as deficient as the *births* are in proportion to *their* number, the proportion of those who reach 10 years of age to the number born would be right in the *bills*, let the deficiencies themselves be ever so considerable. On the contrary, were the deficiencies in the *burials* greater than in the *births*, this proportion would be given too great; and it is only when the former are least that this proportion can be given too little.—Thus; let the number of annual *burials* be 23,000; of *births* 15,700; and the number dying annually under 10, 10,800. Then 4,900 will reach 10 of 15,700 born annually; that is, 5 out of 16.—Were there no deficiencies in the *burials*, and were it fact that only *half* die under 10, it would follow, that there was an
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annual deficiency equal to 4,900 subtracted from 10,800, or 5,900 in the *births*.—Were the *births* a third part too little, and the *burials* also a third part too little, the true number of *births*, *burials*, and of *children dying under 10*, would be 20,933—30,666, and 14,400; and, therefore, the number that would live to 10 years of age would be 6,533 out of 20,933, or 5 of 16 as before.—Were the *births* a third part, and the *burials* so much as two-fifths wrong, the number of *births*, *burials*, and children dying under 10 would be 20,933—32,200 and 15,120; and, therefore, the number that would live to 10 would be 5,813 out of 20,933, or 5 out of 18.—Were the *births* a 3d part wrong, and the *burials* but a 6th, the foregoing numbers would be 20,933—26,833—12,600; and, therefore, the number that would live to 10 would be 8,333 out of 20,933, or 5 out of 12.56: and this proportion seems as low as is consistent with any degree of probability. It is somewhat less than the proportion in Mr. Simpson's Table of *London Observations*, and near *one half* less than the proportion in the Table of *Observations* for Breslaw, where it appears that above 9 of 16 live to be 10, and that *one half* live to be 16. The deficiencies, therefore, in the *births* cannot be much less than double those in the *burials* *; and the least numbers I have given.

* One obvious reason of this fact is, that *none* of the *births* among *Jews*, *Quakers*, *Papists*, and the *three denominations of Dissenters* are included in the bills, whereas *many* of their *burials* are. It is further to be attended to, that the abortive and still-born, amounting to about 600 annually, are included in the *burials*, but never in the *births*. If we add these to the christen-

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must, probably, be nearest to the true number of inhabitants. However, should any one, after all, think that it is not improbable that only 5 of 16 should live in London to be 10 years of age, or that above *two thirds* die under this age, the consequence of admitting this will still be, that the foregoing calculation has been carried too high. For it will from hence follow, that the *expectation* of a child just born in London cannot be so much as I have taken it. This *expectation* is 20, on the supposition that half die under 3 years of age, and that 5 of 16 live to be 29 years of age, agreeably to Mr. Simpson's Table. But if it is indeed true, that *half* die under 2 years of age, and 5 of 16 under 10, agreeably to the *bills*, this expectation must be less than 20, and all the numbers before given will be considerably reduced.

Upon the whole: I am forced to conclude from these observations, that the second number I have given, or 651,580, though short of the number of inhabitants commonly supposed in London, is, very probably, *greater*, but cannot be much *less*, than the true number. Indeed, it is in general evident, that in cases of this kind numbers are very much overrated. The ingenious Dr. Brakenridge *, 14 years ago, when the bills were lower than they are now, from the number of houses, and allowing six to a house, made the number of inhabitants 751,800. But his method of determining the num-

ings, preserving the burials the same, the proportion of the born, according to the bills, who have reached ten for the last sixteen years, will be very nearly one *third* instead of *five sixteenths*.

* Vid. Phil. Transact. vol. XLVIII.

ber of houses is too precarious; and, besides, six to a house is, probably *, too large an allowance. Many families now have two houses to live in. The magistrates of Norwich, in 1752, took an exact account of both the number of houses and individuals in that city. † The number of houses was 7,139, and of

* If this is true, Dr. Brakenridge has also over-rated the number of people in England. The number of houses rated to the window tax he had, he says, been certainly informed was 690,000. The number of cottages not rated was not, he adds, accurately known; but from the accounts given in it appeared, that they could not amount to above 200,000; and, allowing 6 to a house, this would make the number of people in England 5,340,000. But if 5 to a house should be a juster allowance, the number will be 4,450,000. The number of people in Scotland he reckons 1,500,000, and in Ireland 1,000,000.—See a Letter to George Lewis Scott, Esq; Phil. Transact. vol. XLIX. p. 877. 1756.

† Vid. Gentleman's Magazine for 1752, and Dr. Short's *Comparative history of the increase of mankind*, p. 38. In page 58 of this last work the author says, that, in order to be fully satisfied about the number of persons to be allowed to a family, he procured the true number of families and individuals in 14 market towns, some of them considerable for trade and populousness; and that in them were 20,371 families, and 97,611 individuals, or but little more than $4\frac{1}{2}$ to a family. He adds, that, in order to find the difference in this respect between towns of trade and country parishes, he procured from divers parts of the kingdom the exact number of families and individuals in 65 country parishes. The number of families was 17,208; individuals 76,284; or not quite $4\frac{1}{2}$ to a family.—In the place I have just referred to, in the Gentleman's Magazine, there is an account of the number of houses and inhabitants in Oxford exclusive of the colleges, and in Wolverhampton, Coventry, and Birmingham, for 1750. The number of persons to a house was, by this account, $4\frac{1}{2}$ in the two former towns, and $5\frac{1}{2}$ in the two latter. It seems, therefore, to appear that 5 persons to a house is an allowance large enough for London, and too large for England in general.

individuals 36,169, which gives nearly 5 to a house.

—Another method which Dr. Brakenridge took to determine the number of inhabitants in London was from the annual number of burials, adding 2000 to the bills for omissions, and supposing a 30th part to die every year. In order to prove this to be a moderate supposition he observes that, according to Dr. Halley's Observations, a 34th part die every year at Breslaw. But this observation was made too inadvertently. The number of annual burials there, according to Dr. Halley's account, was 1174, and the number of inhabitants, as deduced by him from his Table, was 34,000, and therefore a 29th part died every year. Besides; any one may find, that in reality the Table is constructed on the supposition, that the whole number born, or 1238, die every year; from whence it will follow that a 28th part died every year. * Dr. Brakenridge, therefore, had he attended to this, would have stated a 24th part as the proportion that dies in London every year, and this would have taken off 150,000 from the number he has given. But even this must be less than the just proportion. For let three fourths of all who either die in London or migrate from it, be such as have been born in London; and let the rest be persons who have removed to London from the country or from foreign nations.

* Care should be taken, in considering Dr. Halley's Table, not to take the first number in it, or 1000, for so many just born. 1238, he tells us, was the annual medium of births, and 1000 is the number he supposes all living at one year and under. It was inattention to this that led Dr. Brakenridge to his mistake.

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The *expectation* of the former, it has been shewn, cannot exceed 20 years, and 30 years have been allowed to the latter. One with another, then, they will have an *expectation* of $22\frac{1}{2}$ years. That is, one of $22\frac{1}{2}$ will die every year. * And, consequently,

* The whole number of inhabitants in Rome, in the year 1761, was 157,452; of whom 90,239 were males, and 67,213 females. And the annual medium of births, for 3 years from 1759 to 1761, was 5,167, and of burials 7,153. According to this account, therefore, a 22d part of the inhabitants die in Rome every year. See Dr. Short's *Comparative History of the increase and decrease of mankind in England and several countries abroad*, p. 59, 60.—In Berlin, as the same author relates, p. 69, in six years, from 1734 to 1740, the annual medium of births was 3,504, of burials 3,639, and the number of inhabitants was 68,197; males 32,990, and females 35,207. A 19th part, therefore, of the inhabitants of Berlin are buried every year. As numbers taken by actual survey are generally too little, suppose, in the present instance, an error committed in reckoning the number of inhabitants, equal to a 10th of the whole number, or to the whole number of children under 5; and suppose likewise no omissions in the burials. The consequence will be, that about 1 in 21 are buried at Berlin every year.—At Dublin, in the year 1695, the number of inhabitants was found, by an exact survey, to be 40,508 (see *Philos. Transactions*, N^o 261). I find no account of the annual burials just at that time; but from 1661 to 1681, the medium had been 1613; and from 1715 to 1728 it was 2123. There can, therefore, be no material error in supposing that in 1695 it was 1800; and this makes 1 in 22 to die annually.—In 1745 the number of *families* in the same city appeared, by an exact account laid before the Lord Mayor, to be 9,214. It is probable, this number of families did not consist of more than 50,000 individuals. Suppose them, however, 55,000; and, as at this time the medium of annual burials appears to have been 2,360, 1 in 23 died annually: see Dr. Short's *Comparative History*, p. 15, and *New Observations*, p. 228.—I know not how far these facts may be depended on. If they come at all near the truth, they demonstrate that I have been very moderate in making

supposing the annual recruit from the country to be 7000, the number of *births* 3 times 7000 or 21,000, and the *burials* and *migrations* 28,000 (which seem to be all high suppositions), the number of inhabitants will be $22\frac{1}{2}$ multiplied by 28,000, or 630,000.

I will just mention here one other instance of exaggeration on the present subject.

Mr. Corbyn Morris, in his *Observations on the past*

only 1 in $22\frac{1}{2}$, including emigrants, to die in London annually.

—In 1631 the number of people in the *city and liberties* of London was taken, by order of the Privy Council, and found to be 130,178. —This account was taken five years after a plague that had swept off near a quarter of the inhabitants; and when, therefore, the town being full of recruits in the vigour of life, the medium of annual burials must have been lower than usual, and the births higher. Could, therefore, the medium of annual burials at that time, within the walls and in the 16 parishes without the walls, be settled, exclusive of those who died in such parts of the 16 parishes without the walls, as are not in the *liberties*, the proportion dying annually obtained from hence might be depended on, as rather less than the common and just proportion. But this medium cannot be discovered with any accuracy. *Graunt* estimates that two thirds of these 16 parishes are within the *liberties*; and, if this is right, the medium of annual burials in the *city and liberties* in 1631, was 5,500, and 1 in $23\frac{1}{2}$ died annually; or, making a small allowance for deficiencies in the bills, 1 in 22. —Mr. Maitland, in his *History of London*, vol. II. p. 744, by a laborious, but too unsatisfactory, investigation, reduces this proportion to 1 in $24\frac{1}{2}$; and on the suppositions, that this is the true proportion dying annually, at all times, in London, and that the deficiencies in the burials amount to 3,038 annually, he determines that the number of inhabitants within the bills was 725,903 in the year 1737.

The number of burials not brought to account in the bills is, probably, now much greater than either Dr. Brakenridge or Mr. Maitland suppose it. I have reckoned it so high as 6000, in order to include emigrants, and also to be more sure of not falling below the truth,

growth

growth and present state of the city of London, published in 1751, supposes that no more than a 60th part of the inhabitants of London, who are above 20, die every year, and from hence he determines that the number of inhabitants was near a million. In this supposition there was an error of at least one half. According to Dr. Halley's Table, it has been shewn, that a 34th part of all at 20 and upwards, die every year at Breslaw. In London, a 29th part, according to Mr. Simpson's Table, and also according to all other Tables of London Observations. And in *Scotland* it has been found for many years, that of 974 ministers and professors whose ages are 27 and upwards, a 33d part have died every year. Had, therefore, Mr. Morris stated a 30th part of all above 20 as dying annually in London, he would have gone beyond the truth, and his conclusion would have been 400,000 less than it is.

Dr. Brakenridge observed, that the number of inhabitants, at the time he calculated, was 127,000 less than it had been. The bills have lately advanced, but still they are much below what they were from 1717 to 1743. The medium of the annual *births*, for 20 years, from 1716 to 1736, was 18,000, and of *burials* 26,529; and by calculating from hence on all the same suppositions with those which made 651,580 to be the present number of inhabitants in London, it will be found that the number then was 735,840, or 84,260 greater than the number at present. London, therefore, for the last 30 years, has been decreasing; and though now it is increasing again, yet there is reason to think that the additions lately made to the number of buildings

buildings round it, are owing, in a great measure, to the increase of luxury, and the inhabitants requiring more room to live upon*.

It should be remembered, that the number of inhabitants in London is now so much less as I have made it, than it was 40 years ago, on the supposition that the proportion of the omissions in the *births* to those in the *burials* was the same then that it is now. But it appears that this is not the fact.—From 1728, the year when the ages of the dead was first given in the *bills*, to 1742, near five-sixths of those who were born died under 10, according to the *bills*.—From 1742 to 1752 three quarters; and ever since 1752 this proportion has stood nearly as it is now, or at somewhat more than two-thirds. The omissions in the *births*, therefore, compared with those in the *burials* were greater formerly; and this must render the difference between the number of inhabitants now and formerly less considerable than it may seem to be from the face of the bills. One reason why the proportion of the amounts of the *births* and *burials* in the bills comes now nearer than it did to

* The medium of annual burials in the 97 parishes within the walls was,

From 1655 to 1664,	3264
From 1680 to 1690,	3139
From 1730 to 1740,	2316
From 1758 to 1768,	1620

This account proves, that though, since 1655, London has doubled its inhabitants, yet, *within the walls*, they have decreased; and so rapidly for the last 30 years as to be now reduced to one half.—The like may be observed of the 17 parishes immediately without the walls. Since 1730 these parishes have been decreasing so fast, that the annual burials in

the true proportion, may, perhaps, be that the number of Dissenters is considerably lessened. The Foundling Hospital also may have contributed a little to this event, by lessening the number given in the bills as having died under 10, without taking off any from the *births*; for all that die in this hospital are buried at *Pancras* church, which is not within the *bills*. See the preface to a collection of the yearly bills of mortality from 1657 to 1758 inclusive, p. 15.

I will add, that it is probable that London is now become less fatal to children than it was; and that this is a further circumstance which must reduce the difference I have mentioned; and which is likewise necessary to be joined to the greater deficiencies in the births, in order to account for the very small proportion of children who survived 10 years of age, during the two first of the periods I have specified. Since 1752, London has been thrown more open. The custom of keeping country-houses, and of sending children to be nursed in the country, has prevailed more. But, particularly, the destructive use of spirituous liquors among the poor has been checked.

I have shewn that in London, even in its present

state, they have sunk from 8,672 to 5,432, and are now lower than they were before the year 1660. In Westminster, on the contrary, and the 23 out-parishes in Middlesex and Surrey, the *annual burials* have, since 1660, advanced from about 4000 to 16,000. — These facts prove that the inhabitants of London are now much less crowded together than they were. It appears, in particular, that *within the walls* the inhabitants take as much room to live upon as double their number did formerly. — The very same conclusions may be drawn from an examination of the *christenings*.

state,

state, and according to the most moderate computation, half the number born die under *three* years of age; and I have observed that at Breslaw half live to 16. At Edinburgh, if I may judge from such of its bills as I have seen, almost as great a proportion of children die as even in London. But it appears from *Graunt's** accurate account of the births, weddings, and burials in three country parishes for 90 years; and also, with abundant evidence, from Dr. Short's collection of observations in his *Comparative History*, and his treatise entitled, *New Observations on Town and Country Bills of Mortality*†; that in country villages and parishes, the major part live to mature age, and even to marry. So great is the difference, especially to children, between living in great towns and in the country. But nothing can place this observation in a more striking light than the curious account given by Dr. Thomas Heberden, and published in the Philosophical Trans-

* See *Natural and Political Observations on the Bills of Mortality*, by Captain John Graunt, F. R. S.

† The public is much obliged to this author for the pains he has taken in collecting observations on the mortality and increase of mankind, in different countries and situations. In his *New Observations*, p. 309, he mentions an ingenious parish clerk, in the country, who, by a particular account which he took, found that of 374, who had been baptized in his parish in one year, 80, or nearly a quarter part, died under four years of age. Forty-six died the first year; thirteen the second; sixteen the third; and five the fourth. After four, life grows more stable, and at ten acquires its greatest stability; and in this case it cannot be reckoned that above a 10th, or, at most, an 8th more than the quarter that died under four, would die under age; and therefore, probably, near two-thirds arrived at maturity.

actions (vol. LVII. p. 461), of the increase and mortality of the inhabitants of the island of Madeira.

In this island, it seems, the weddings have been to the births, for 8 years, from 1759 to 1766, as 10 to 46.8; and to the burials as 10 to 27.5. Double these proportions, therefore, or the proportion of 20 to 46.8, and of 20 to 27.5 are the proportions of the number marrying annually, to the number born and the number dying. Let 1 marriage in 10 be a 2d or 3d marriage on the side of either the man or the woman; and 10 marriages will imply 19 individuals who have grown up to maturity, and lived to marry once or oftener; and the proportion of the number marrying annually the first time, to the number dying annually, will be 19 to 27.5, or near 3 to 4.

It may seem to follow from hence, that in this island near three-fourths of those who die have been married, and, consequently, that not many more than a quarter of the inhabitants die in childhood and celibacy; and this would be a just conclusion were there no increase, or had the births and burials been equal. But it must be remembered, that the general effect of an increase, while it is going on in a country, is to render the proportion of persons marrying annually to the annual deaths *greater*, and to the annual births *less* than the true proportion marrying out of any given number born. This proportion generally lies between the other two proportions, but always nearest to the first*; and, in the present case, it is sufficiently evident that it cannot be much less than two-thirds.

* If a country where there is no increase or decrease of the inhabitants, and where also life, in its first periods, is so stable,

In London, then, *half* die under three years of age, and in Madeira about *two-thirds* of all who are

and marriage so much encouraged, as that half all who are born live to be married, the *annual* births and burials must be equal, and also *quadruple* the number of weddings, after allowing for 2d and 3d marriages. Suppose in these circumstances (every thing else remaining the same) the *probabilities of life*, during its first stages, to be improved. In this case, more than *half* the born will live to be married, and an increase will take place. The births will exceed the burials, and both fall below *quadruple* the weddings; or, which is the same, below *double* the number annually married.—Suppose next (the *probabilities of life* and the *encouragement to marriage* remaining the same) the *prolifickness* only of the marriages to be improved. In this case it is plain, that an increase also will take place; but the *annual* births and burials, instead of being less, will now both rise above *quadruple* the weddings, and therefore the proportion of the born to that part of the born who marry (being by supposition two to one) will be less than the proportion of either the *annual* births or the *annual* burials to the number marrying *annually*.—Suppose again (the *encouragement to marriage* remaining the same) that the *probabilities of life* and the *prolifickness of marriages* are both improved. In this case, a more rapid increase will take place, or a greater excess of the births above the burials; but at the same time they will keep nearer to *quadruple* the weddings, than if the latter cause only had operated, and produced the same increase.—I should be too minute and tedious, were I to explain these observations at large. It follows from them, that, in every country or situation where, for a course of years, the *burials* have been either *equal to* or *less* than the *births*, and both under *quadruple* the marriages; and also that wherever the burials are *less* than quadruple the annual marriages, and at the same time the births *greater*, there the major part of all that are born live to marry. In the instance which I have considered above, and which occasions this note, the annual births are so much *greater* than *quadruple* the marriages, and at the same time the annual burials so much *less*, that the proportion that lives to marry of those who are born can scarcely be much less than I have said, or two-thirds.

born

born live to be married. Agreeably to this, it appears also from the account I have referred to, that the *expectation* of a child just born in Madeira is about 39 years, or near double the *expectation* of a child just born in London. For the number of inhabitants was found, by a survey made in the beginning of the year 1767, to be 64,614. The annual medium of *burials* had been, for eight years, 1293; of *births* 2201. The number of inhabitants, divided by the annual medium of *burials*, gives 49.89, or the *expectation* nearly of a child just born, supposing the *births* had been 1293, and constantly equal to the *burials*, the number of inhabitants remaining the same. And the same number, divided by the annual

I have shewn how the allowance is to be made for 2d and 3d marriages; but it is not so considerable as to be of any particular consequence; and, besides, it is, in part, compensated by the natural children which are included in the births, and which raise the proportion of the births to the weddings higher than it ought to be, and therefore bring it nearer to the true proportion of the number born *annually*, to those who marry annually, after deducting those who marry a 2d or 3d time.

In drawing conclusions from the proportion of *annual* births and burials in different situations, some writers on the increase of mankind have not given due attention to the difference in these proportions arising from the different circumstances of increase or decrease among a people. One instance of this I have now mentioned; and one further instance of it is necessary to be mentioned. The proportion of *annual* births to weddings has been considered as giving the true number of children derived from each marriage, taking all marriages one with another. But this is true only when, for many years, the births and burials have kept nearly equal. Where there is an excess of the births occasioning an increase, the proportion of *annual* births to weddings must be less than the proportion of children derived from each marriage; and the contrary must take place where there is a decrease.

medium of *births*, gives 29.35, on the *expectation* of a child just born, supposing the burials 2201, the number of births and of inhabitants remaining the same; and the true *expectation* of life must be somewhere near the mean between 49.89 and 29.35.

Again: A 50th part of the inhabitants of Madeira, it appears, die annually. In London, I have shewn, that above twice this proportion dies annually. In smaller towns a smaller proportion dies, and the births also come nearer to the burials. At Breslaw, I have observed, that, by Dr. Halley's Table, a 28th part dies annually; and the annual medium of births, for a complete century, from 1633 to 1734, has been 1089; of burials 1256. * At Norwich, the annual medium of births, dissenters included, for four years, from 1751 to 1754, was 1150; of burials 1214. And as the number of inhabitants was at that time 36,169 (see pag. 9), a 30th part of the inhabitants died annually. In general, there seems reason to think that in towns (allowing for particular advantages of situation, trade, police, cleanliness, and openness, which some towns may have), the excess of the burials above the births and the annual deaths are more or less as the towns are greater or smaller. In London itself, about 160 years ago, when it was scarcely a fourth part of its present bulk, the births were nearly equal to the burials.

* Vid. Dr. Short's *Comparative History*, p. 63. And the *Abridgment of the Philosophical Transactions*, vol. VII. part iv. p. 46. During the five years on which Dr. Halley has founded his Table, or from 1687 to 1691, the births happened a little to exceed the burials.

But

But in country parishes and villages the births almost always exceed the burials; and I believe it seldom happens that so many as a 30th, or much more than a 40th part of the inhabitants die annually*. In the four provinces of New England there is a very rapid increase of the inhabitants: but, notwithstanding this, at Boston, the capital, the inhabitants would decrease were there no supply from the country: for, if the account I have seen is just, from 1731 to 1762, the burials have all along exceeded the births†. So remarkably do towns, in consequence of their unfavourableness to health, and the luxury which generally prevails in them, check the increase of countries.

* In 1738 there was an account taken of the number of families and inhabitants in the Prussian dominions. The number of inhabitants was 2,138,465. The medium of annual births, weddings, and burials was nearly 84,000; 21,000, and 55,481. Near a 40th part, therefore, died every year. Vid. Dr. Short's *Comparative History*, p. 69, and *Abridgment of the Philosophical Transactions*, *ibid.*—The proportion of weddings and burials to the births shews that, in these countries, there was a quick increase, notwithstanding the waste in the cities.—In the year 1733 a survey was taken of the inhabitants of the parish of *Stoke Damerel* in *Devonshire*, and the number of men, women, and children, was found to be 3361.—The christenings for the year were 122—the weddings 28—burials 62.—No more, therefore, than the 54th part of the inhabitants died in the year.—In part of this year an epidemical fever prevailed in the parish. See Martyn's *Abridgment of the Philos. Transactions*, vol. IX. p. 325.—According to Graunt's account of a parish in *Hampshire*, not reckoned, he says, remarkably healthful, a 50th part of the inhabitants had died annually for 90 years. *Natural and Political Observations*, &c. Chap. xii.

† See a particular account of the births and burials in this town from 1731 to 1752 in the *Gentleman's Magazine* for 1753, p. 413.

Health-

Healthfulness and Prolifickness are, probably, causes of increase seldom separated. In conformity to this observation, it appears from comparing the births and weddings, in countries and towns where registers of them have been kept, that in the former, marriages, one with another, seldom produce less than four children each; generally between four and five, and sometimes above five. But in towns seldom above four; generally between three and four; and sometimes under three*.

I have sometimes heard the great number of old people in London mentioned to prove its favourableness to health and long life. But no observation can be much more erroneous. There ought, in reality, to be more old people in London, in proportion to the number of inhabitants, than in any smaller towns, because at least one quarter of its inhabitants are persons who come into it, from the country, in the most robust part of life, and with a much greater probability of attaining old age, than if they had come into it in the weakness of infancy. But, notwithstanding this advantage, there are much fewer persons who attain to great ages in London than in any other place where observations have been made.—— At Vienna, of 22,704 who died in the four years

* Any one may see what evidence there is for this, by consulting the accounts in Dr. Short's two books already quoted; and in the *Abridgment of the Philosophical Transactions*, vol. VII. part iv. p. 46.—In considering these accounts, it should not be forgotten that allowances must be made for the different circumstances of increase or decrease in a place, agreeably to the observation at the end of the note in pag. 19.

1717, 1718, 1724, 1725*, 109 reached 90 years, that is, 48 in 10,000. But in London, for the last 30 years, only 35 of the same number have reached this age.—At Breslaw it appears, by Dr. Halley's Table, that 41 of 1238 born, or a 30th part, live to be 80 years of age.—In the parish of *All-saints* in Northampton†, an account has been kept for many years of the ages at which all die; and, I find, that of 1377, who died there in 13 years, 59 have lived to be 80, or a 23d part.—According to Mr. Kerseboom's Table of Observations, published at the end of the last edition of Mr. De Moivre's Treatise on the Doctrine of Chances, a 14th part of all that are born live to be 80; and, had we any observations in *country* parishes, this, probably, would not appear to be too high a proportion‡. But in London, for the last 30 years, only 25 of every 1000

* Vid. Abridgment of the Philosophical Transactions, vol. VII. part iv. p. 46. — It appears also that more than three-fifths of all who died in these years at Vienna were boys and girls, by whom, I suppose, are meant persons under 16. About the same proportion dies under 16 at Berlin.

† In this town, as in most other towns of any magnitude, the births, including Dissenters, fall short of the burials; and the greater part die under age.

‡ This, however, will appear itself inconsiderable, when compared with the following account: "In 1761, the burials in the district of Christiana, in Norway, amounted to 6,929, and the christenings to 11,024. Among those who died, 394, or 1 in 18, had lived to the age of 90; 63 to the age of 100, and seven to the age of 101.—In the diocese of Bergen, the persons who died amounted only to 2,580, of whom 18 lived to the age of 100; one woman to the age of 104, and another woman to the age of 108."

See the *Annual Register* for 1761, p. 191.

who

who have died, have lived to be 80, or a 40th part ; which may be easily discovered by dividing the sum of all who have died during these years at all ages, by the sum of all who have died above 80.

Among the peculiar evils to which great towns are subject, I might further mention the PLAGUE. Before the year 1666 this dreadful calamity laid London almost waste once in every 15 or 20 years ; and there is no reason to think that it was not generally bred within itself. A most happy alteration has taken place, which, perhaps, in part, is owing to the greater advantages of cleanliness and openness, which London has enjoyed since it was rebuilt, and which lately have been very wisely improved.

The facts I have now taken notice of are so important that, I think, they deserve more attention than has been hitherto bestowed upon them. Every one knows that the strength of a state consists in the number of people. The encouragement of population, therefore, ought to be one of the first objects of policy in every state ; and some of the worst enemies of population are the luxury, the licentiousness, and debility produced and propagated by great towns.

I have observed that London is now* increasing. But it appears that, in truth, this is an event more to be dreaded than desired. The more London in-

* This increase is greater than the bills shew, on account of the omission in them of the two parishes which have been most encreased by new buildings ; I mean *Marybone* and *Pancras* parishes. The former of these parishes is, I suppose, now one of the largest in London.

creases,

creases, the more the rest of the kingdom must be deserted; the fewer hands must be left for agriculture; and, consequently, the less must be the plenty and the higher the price of all the means of subsistence.

—*Moderate* towns, being seats of refinement, emulation, and arts, may be public advantages. But *great* towns, long before they grow to half the bulk of London, become checks on population of too hurtful a nature, nurseries of debauchery and voluptuousness; and, in many respects, greater evils than can be compensated by any advantages*.

* The mean annual *births*, *weddings*, and *burials* in the following towns, for some years before 1768, were nearly,

	Births.	Weddings.	Burials.
At Paris,	— 19,200	— 4,300	— 19,500
Vienna,	— 5,600	—	— 6,800
Amsterdam,	— 4,500	— 2,400	— 7,600
Copenhagen,	— 2,700	— 868	— 3,100

In the Paris bills there is, I am informed, an omission of all that die in the *Foundling Hospital*, amounting to above 2000 annually. The excess, therefore, of the burials above the births is greater than the bills shew. This excess, however, is much less than could have been expected in so large a town. I am not sure to what cause this ought to be ascribed; but I cannot wonder at it, if it be indeed true, that a fifth of all born in Paris are sent to the *Foundling Hospital*, and that a third of the inhabitants die in hospitals, and also that all married men are excused from serving in the militia, from whence draughts are made for the army. These are encouragements to marriage and population, which no other city enjoys; and it is strange that in this kingdom some policy of the same kind with that last mentioned should not be pursued.—A further singularity in the state of Paris is, that the births in it are above four times the weddings, nothing like which is the case in any other town whose bills I have seen. It may seem, therefore, that here, as well as in the most healthful

E

Dr. Heberden

Dr. Heberden observes that, in Madeira, the inhabitants double their own number in 84 years. But

and increasing country parishes, each marriage produces more than four children; but this is a conclusion which, in the present case, cannot be depended on. It should be considered that, probably, some who leave the country to settle at Paris, come to it already married; and that no small proportion of the births may be illegitimate. These causes, however, may only balance the allowance to be made for the second and third marriages among the annual weddings; and, if it is indeed fact, that the people at Paris are so prolific as they appear to be in the bills, it will only prove more strongly that, like other great towns, it is very unfavourable to health; for the more prolific a people are, the greater must be the mortality among them if they do not increase.

—Let us suppose the true number of deaths at Paris, including emigrants and such as die in the *Foundling Hospital*, to be 21,000; the number married annually $2 \times 4,300$ or 8,6000; and the births, as before, 19,200. 1,900 then will be the number of annual recruits from the country. Of these let only 1,200 be supposed to marry: and 8,600 lessened by 1,200, or 7,400, will be the number of those born at Paris who marry annually; and 11,800, or above *three-fifths* will be the number dying in childhood and celibacy. This, though it gives an unfavourable representation of Paris when compared with the country, makes it appear to advantage when compared with some other great towns. I am not sufficiently informed of the state of Paris to know how near this calculation comes to the truth. Every such doubt would be removed, were the ages of the dead given in the Paris bills. It is much to be wished this was done. The births and burials here come so near to one another, that there can scarcely be a properer place for such bills; and a Table of Observations might be formed from them that would give the values of lives much more exactly than the London Tables.

I cannot help adding that, excepting the omission I have mentioned in the burials, the Paris bills are complete; but it is well known that the London bills are extremely otherwise. London, therefore, must be much larger in comparison of Paris than it appears to be in the bills.

this

this (as you, Sir, well know) is a very slow increase compared with that which takes place among our colonies in AMERICA. In the back settlements, where the inhabitants apply themselves entirely to agriculture, and luxury is not known, they double their own number in 15 years; and all through the northern colonies in 25 years*. This is an instance of increase so rapid as to have scarcely any parallel. The births in these countries must exceed the burials much more than in Madeira, and a greater proportion of the born must reach maturity.——In 1738, the number of inhabitants in New Jersey was taken by order of the government, and found to be 47,369. Seven years afterwards the number of inhabitants was again taken, and found to be increased, by procreation only, above 14,000, and very near one *half* of the inhabitants were found to be under † 16 years of age. In 22 years, therefore, they must have doubled their own number, and the births must have exceeded the burials 2000 annually. As the increase here is much quicker than in Madeira, we may be sure that a smaller proportion of the inhabitants must die annually. Let us, however, suppose it the same, or a 50th part. This will make the annual burials

* See a discourse on *Christian union*, by Dr. Styles, Boston, 1761, p. 103. 109, &c.——See also *The interest of Great Britain considered with regard to her Colonies, together with Observations concerning the increase of mankind, peopling of countries, &c.* p. 35. 2d edit. London, 1761.

* According to Dr. Halley's Table the number of the living under 16 is but a *third* of all the living at all ages; and this may be nearly the case in all places which just support themselves in the number of their inhabitants, and neither increase or decrease.

to have been, during these seven years, 1000, and the annual births 3000, or an 18th part of the inhabitants.——Similar observations may be made on the much quicker increase in Rhode Island, as related in the preface to Dr. Birch's *collection of the bills of mortality*, and also in the valuable pamphlet, last quoted, on *the interest of Great Britain with regard to her colonies*, p. 36.——What a prodigious difference must there be between the vigour and the happiness of human life in such situations, and in such a place as London?——The original number of persons who, in 1643, had settled in New England, was 21,200. Ever since it is reckoned, that more have left them than have gone to them*. In the year 1760 they were increased to half a million. They have, therefore, all along doubled their own number in 25 years; and, if they continue to increase at the same rate, they will, 70 years hence, in New England alone, be four millions; and in all North America above twice the number of inhabitants in Great-Britain†.——But I am wandering

* See Dr. Styles's pamphlet just quoted, p. 110, &c.

† The rate of increase, supposing the procreative powers the same, depends on two causes: The "encouragement to marriage;" and the "*expectation* of a child just born." When one of these is given, the increase will be always in proportion to the other. That is; As much *greater* or *less* as the *ratio* is of the numbers who reach maturity, and of those who marry to the number born, so much *quicker* or *slower* will be the increase.——Let us suppose the operation of these causes such as to produce an annual excess of the *births* above the *burials* equal to a 36th part of the whole number of inhabitants. It may seem to follow from hence, that the inhabitants would double their own number in 36 years; and thus some have calculated. But the truth is, that they would double their own number in much less time.

from

from my purpose in this letter. The point I had chiefly in view was, the present state of London as

Every addition to the number of inhabitants from the births produces a proportionably greater number of births, and a greater excess of these above the burials; and if we suppose the excess to increase annually at the same rate with the inhabitants, or so as to preserve the *ratio* of it to the number of inhabitants always

the same, and call this *ratio* $\frac{1}{r}$, the period of doubling will be the *quotient* produced by dividing the logarithm of 2 by the *difference* between the logarithms of $r + 1$ and r , as might be easily demonstrated. In the present case, r being 36, and $r + 1$ being 37, the period of doubling comes out 25 years. If r is taken equal to 22, the period of doubling will be 15 years.—

But it is certain that this ratio may, in many situations, be greater than $\frac{1}{r}$; and, instead of remaining the same, or becoming less, it may *increase*, the consequence of which will be, that the period of doubling will be shorter than this rule gives it.—According to Dr. Halley's Table, the number of persons between 20 and 42 years of age is a third part of the whole number living at all ages. The prolific part, therefore, of a country may very well be a 4th of the whole number of inhabitants; and supposing four of these, or every other marriage between persons all under 42, to produce *one* birth every year, the annual number of births will be a 16th part of the whole number of people; and, therefore, supposing the burials to be a 48th part, the annual excess of the births above the burials will be a 24th part, and the period of doubling 17 years.—The number of inhabitants in New England was, as I have said from Dr. Stiles's pamphlet, half a million in 1760. If they have gone on increasing at the same rate ever since, they must be now 640,000; and it seems to appear that in fact they are now more than this number. For, since I have writ the above observations, I have seen a particular account, grounded chiefly on surveys lately taken with a view to taxation and for other purposes, of the number of males, between 16 and 60, in the four provinces. According to this account, the number of such males is 218,000. The whole number of people, therefore, between 16 and 60, supposing 14 males to 13 females, must be nearly

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to healthfulness, number of inhabitants, and its influence on population. The observations I have made may, perhaps, help to shew how the most is to be made of the lights afforded by the London bills, and serve as a specimen of the proper method of calculating from them. It is indeed extremely to be wished that they were less imperfect than they are, and extended further. More parishes round London might be taken into them; and, by an easy improvement in the parish registers now kept, they might be

420 000. In order to be more sure of avoiding excess, I will call them only 400,000. In Dr. Halley's Table the proportion of all the living under 16 and above 60, to the rest of the living, is 13.33 to 20; and this will make the number of people now living in the four provinces of New England to be 666,000. But, on account of the rapid increase, this proportion must be considerably greater in New England, than that given by Dr. Halley's Table. In New Jersey, I have said the number of people under 16 was found to be almost equal to the number above 16. Suppose, however, that in New England, where the increase is somewhat slower, the proportion I have mentioned is only 16 to 20, and then the whole number of people will be 720,000.

I cannot conclude this note without adding a remark to remove an objection which may occur to some in reading Dr. Herberden's account of Madeira, to which I have referred. In that account 5945 is given as the number of children under seven in the island, at the beginning of the year 1767. The medium of annual births, for eight years, had been 2201; of burials 1293. In six years, therefore, 13,206 must have been born; and if, at the end of six years, no more than 5945 of these were alive, 1210 must have died every year. That is; almost all the burials in the island, for six years, must have been burials of children under seven years of age. This is plainly incredible; and, therefore, it seems certain, that the number of children under seven years of age must, through some mistake, be given, in that account, 3000 or 4000 too little.

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extended through all the parishes and towns in the kingdom. The advantages arising from hence would be very considerable. It would give the precise law according to which human life wastes in its different stages, and thus supply the necessary *data* for computing accurately the values of all *life-annuities* and *reversions*. It would, likewise, shew the different degrees of healthfulness of different situations, mark the progress of population from year to year, keep always in view the number of people in the kingdom, and, in many other respects, furnish instruction of the greatest importance to the state. Mr. De Moivre, at the end of his book on the doctrine of chances, has recommended a general regulation of this kind; and observed, particularly, that at least it is to be wished, that an account was taken, at proper intervals, of all the living in the kingdom, with their ages and occupations; which would, in some degree, answer most of the purposes I have mentioned.—But, dear Sir, I am sensible it is high time to finish these remarks. I have been carried in them far beyond the limits I at first intended. I always think with pleasure and gratitude of your friendship. The world owes to you many important discoveries; and your name must live as long as there is any knowledge of philosophy among mankind. That your happiness in this, and every other respect, may continually increase, is the sincere wish of,

SIR,

Your much obliged,
and very humble servant,

Newington-Green,
April 3, 1769.

Richard Price.